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Overview of arsenic distribution in some part of Biu Volcanic Province North-Eastern Nigeria

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Abstract: Overexposure to arsenic can cause various diseases such as cancer of (skin, lung, bladder, and kidney), hair loss and nails deformity. These diseases are common among adults, youth and children in some rural communities in Biu Volcanic Province North-Eastern Nigeria. This is what motivated the Authors to investigate the concentration of arsenic in surface and ground waters of Biu volcanic environment, northern eastern Nigeria and to delineate areas of high risk to arsenic exposure. Thirty seven water samples; thirteen surface water samples and twenty four ground water samples were analyzed using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) at Geochemistry Laboratory, University of Jos, Nigeria. Arsenic concentrations range from 0.03 to 0.477 mg/L in the surface water and 0.006 to 0.424 mg/L in the ground water. This study indicates that people in Yimirshika Village might be at a considerable risk of arsenic poisoning.

Keywords: Arsenic Distribution, Volcanic Province, Health Hazard, Biu, Nigeria

1. Introduction

The Biu volcanic province constitutes one of the largest volcanic provinces in Nigeria. It marks the structural culmination between the Benue and the Chad sedimentary basins (fig.1); it lies in the north eastern Nigeria. The province covers a superficial area of 5000Km2 with a thickness of 250m, made up of several simple volcanoes with very large craters (caldera) of greater than 1km, suggesting that quite a large volume of magma, volcanic ash and pyroclastic materials erupted.

Through physical and chemical weathering processes, rocks break down to form the soils on which the crops that constitute the food supply are raised for humans and animals consumption. Drinking water travels through rocks and soils as part of the hydrological cycle and in the process leached elements in solution (Lar, 2009). Volcanism and related igneous activities re distribute some of the harmful elements, such as arsenic, beryllium, cadmium, mercury, lead, radon, and uranium. Almost all metals present in the environment have been biogeochemically cycled since the formation of the Earth. Human activity has introduced additional processes that have increased the rate of redistribution of metals between environmental compartments.

However, over most of the Earth's land surface the primary control on the distribution of metals is the geochemistry of the underlying and local rocks except in all but the worst cases of industrial contamination and some particular geological situations.

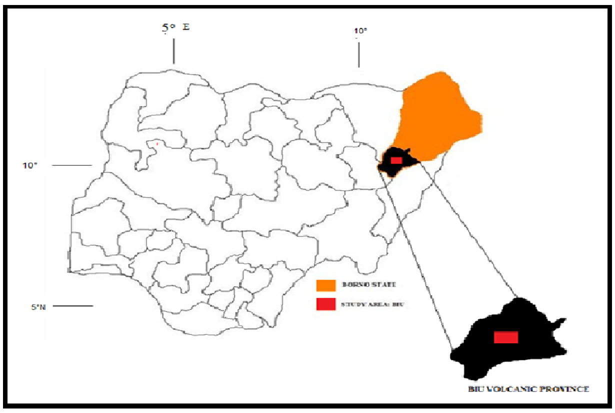

Fig 1. *Map of Nigeria showing the location of the study area*

The purpose of this study is to determine the distribution of arsenic in the natural waters of Biu Volcanic Province Nigeria, and the possible health hazard to the inhabitants.

2. Geology and Hydrogeology of Biu Volcanic Province

2.1. Geology

Biu Plateau is situated on the structural and topographic divide between the Benue and Chad sedimentary basins. The structural divide is a broad E-W ridge or swell of basement, which extends to the western edge of the Biu Plateau. The two basins are divided by a sub-surface size, the Zambuk ridge to the west (Carter et al., 1963).

The basalt of the Biu Plateau mainly overlies Basement rocks. They are mostly occurring as "flood basalts" in a number of flows and in fact cover nearly 85% of the area with its centre around Biu (Turner, 1978). The basalt at some places has built up large number of flows. The dimension of the flows and the marked absence of pyroclastics in and around Biu, Tum, Marama, and Shaffa areas, indicate that the eruption of basaltic magma in these places was not violent. However, the basaltic sequence in the North-western part of Biu is surrounded by several youthful scoria, cinder cones, tephra rings etc., the pyroclastics are generally restricted to the area west of Biu- Damaturu road, suggesting that the eruptions in these places are violent in nature.

2.2. Hydrogeology of the Study Area

2.2.1. Introduction

The water resources of the study area can be divided into surface and groundwater resources. The surface water of this area occurs in the form of streams and lakes. They serve as water supply sources for both drinking and domestic uses. Most of the streams are seasonal. The streams and lakes are recharged by direct precipitation during the rainy season.

2.2.2. Surface Water

2.2.2.1. Lake Tila

The only permanent body of water is Lake Tila situated at Kwaya Bura village about thirteen kilometers to the south-west of Biu. The lake occupies a crater a short distance west of Mount Tila.

The lake-level in the height of the dry season is only one meter below what appears to be the peak level bench-mark. The high water level each year is dependent on the rainfall and it can be assumed that it ranges within one meter, (Du Preez, 1965).

The lake receives very little runoff during the rains and the rise of the lake level is due mainly to direct precipitation. There is little seepage zone around the shore which flows continuously into the lake. Shallow percolation wells dug into the zone constitute the main domestic water supply for several villages in the vicinity.

Analyses of water samples from Lake Tila and from the shallow seepage wells along the shoreline carried out by the (Du Preez, 1965) are given in. The analysis of the lake water shows a high concentration of sodium carbonate, and comparatively low sodium chloride content. In the water from the seepage wells, sodium carbonate probably also predominate, while sodium chloride is negligible. Owing of the high carbonate content the lake water is unsuitable for irrigation. It is estimated that the amount of soda in the lake is in the order of about 2,000 tons, but it is doubtful whether it is of any economic value, (Du Preez, 1965).

2.2.2.2. Perennial Stream Water

Most of the rivers in Biu dry up for a part of the year, but a considerable number of streams rising on the basalt Plateau are weakly perennial some of the streams are fed by seepage springs which issues from the basalts.

These discharges are small and are absorbed in the alluvium on reaching the low-lying country below the basalt Plateau. Permanent pools are frequently present in these streams, and they provide water supplies for neighboring villages.

2.2.3. Groundwater in the Basalts

The basalts are usually strongly jointed and fissured. The earlier flows, usually consist of dense compact basalt, while the early flows are irregular jointed. The joints serve as loci of weathering and as channels for the circulation and storage of groundwater (Du Preez, 1965). The compact basalts are incapable of storing water, the groundwater held in the joints gives rise to numerous small springs on the higher parts of the Plateau.

The basalts form the most important aquifer in Biu Plateau. The amount of water obtained in them depends on the degree of decomposition, jointing and the nature of the rock. The basalts show a superficial weathered zone consisting of black-grey and brown clay with residual boulders of partially decomposed rock.

The scoriaceous and amygdaloidal basalts usually weather to brown and blue clays which tend to disintegrate on exposure to the atmosphere. Moderate amounts of water may be present in the basalt alluvium but in general the quantity of water available is small and the water table is subject to considerable variation. Many villagers get their water partly or wholly from this source during the dry season. The water from this source can be obtained through hand dug wells which were seen all over the area and few boreholes.

2.2.4. Data Collection

Data of the water table was obtained by field measurement of static water levels in wells within the study area, as well as the geographical positions and elevations at various locations.

2.2.4.1. Data Processing

Coordinates of the observed wells and well elevations were manipulated using a computer program (sufer 8).The X, Y, Z coordinates in the surfer 8 is entered as longitude, latitude and elevation respectively, from which the computer program plots a water table contour map (figure 2).

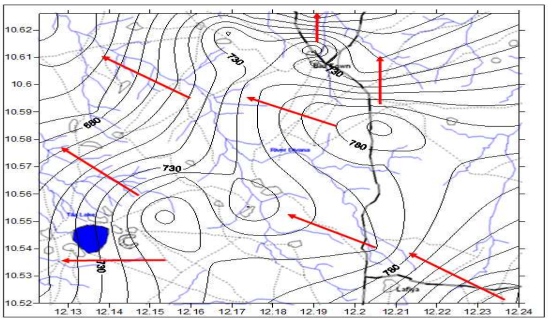

Fig 2. Groundwater Contour Map of the study area indicating direction of Water Flow (resent study)

2.2.4.2. Interpretation of Groundwater Map

A water table contour map shows the elevation and the configuration of the water table at a certain data. The map is prepared by plotting the absolute water levels of all observation points of equal water table elevation. This water table contour map (figure 2) is an important tool in groundwater investigations as one can derive from it the gradient of the water table and the direction of the groundwater flow.

Generally, the pattern of groundwater flow follows the surface topography with seasonal variations in water levels characterized by rising water levels during the wet months and declining water levels during the dry months.

3. Methodologies

3.1. Field Sampling

Sampling was accomplished during the dry season (March 28-April 25). A total of thirty seven (37) water samples and thirteen (13) soils samples were collected over an area of 150 km^2 for analysis to determine their elemental concentrations.

The sampling locations of the study area are presented in (fig. 3).

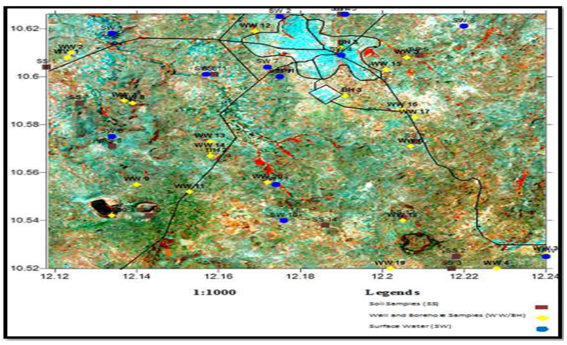

Fig 3. sampling locations of the study area (This study)

In view of the usual low trace element concentrations in water, various measures were taken to prevent the slightest contamination in the collected samples. 250ml polyethylene bottle capacity containers were used for the collection of samples. Bottles were first washed with a mixture of acid and distilled water (1% HNO_3). The bottles were finally rinsed with distilled water and kept to dry in an oven at 25^{0}C. One important step taken was the immediate wrapping of the bottle with sterilized thin film with the top of the bottle folding over a non-contaminating stiffened material attached to the twisted end. With these procedures the bottles were protected and ready for sample collection.

After the sample was collected, the old thin film was removed and a new one re-wrap. All samples collected were labeled according to location, nature of sample, date of collection and number. Samples collected were kept in the refrigerator at room temperature (23^{0}C).

3.2. Laboratory Analysis

Analysis of the water samples was carried out using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) at Geochemistry Laboratory, University of Jos, Nigeria, to determine the major and trace elements concentrations.

3.3. Results and Discussion

The range of arsenic values from different water sources is displayed in Table 1.

Table 1. Arsenic Concentration in natural water

Samples	Locality	As (mg/L)
BH1	Waka	0.224
BH2	Hena	0.089
BH3	Army Barrack	0.039
BH4	Biu BCJ	0.070
W1	BCJ	0.040
W2	Wakama	0.315
W3	Yimirshika	0.037
W4	Waka	0.023
W5	Biu	0.227
W6	Biladega	0.066
W7	Tabra Fulani	0.083
W8	Malan	0.039
W9	Tila	0.059
W10	Tila	0.043
W11	Tila	0.006
W13	Hena	0.123
W14	Hena	0.229
W16	Yimirshika	0.136
W17	Gwarta	0.290
W18	Kunar	0.424
SW1	Wakama	0.067
SW2	Waka	0.389
SW3	Waka	0.087
SW5	Tabra Fulani	0.041
SW6	Hena	0.074
SW7	Hena	0.116
SW8	Hena	0.067
SW9	Army Barrack	0.021
SW10	Army Barrack	0.032
SW11	Kunar	0.036
SPW	Yimirshika	0.477

It is noted that arsenic is concentrated in all the water bodies above WHO admissible standard of 0.01 mg/L.

Range of arsenic concentration in surface water is from 0.02 to 0.0477 mg/L. The lowest concentration of 0.02 mg/L was observed in Takwa village while the highest concentration of 0.477 mg/L was detected in surface spring water in Yimirshika village. Concentration of arsenic varied from 0.01-0.424 mg/L in well water samples collected from various sites. The lowest concentration of 0.01 mg/L was detected at Tila while the highest concentration of 0.424 mg/L was determined from Kunar.

The observed concentration of arsenic in borehole water samples collected from various sites in Biu ranged from 0.04-0.2 mg/L. The highest concentration of 0.2 mg/L was recorded in Waka Biu while the lowest concentration of 0.04 mg/L was observed in Biu Army Barrack. Concentration of arsenic and its spatial distribution in surface and groundwater is shown in Fig 4.

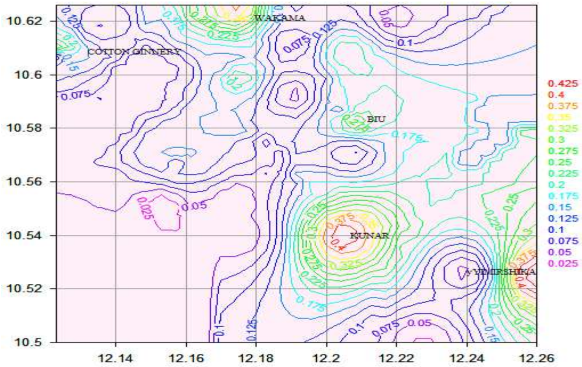

Fig 4. *Shows concentration of arsenic and its spatial distribution in surface and groundwater*

4. Trace Element Exposures

This study discover the concentration of arsenic from 0.1 to 0.48 mg/L, the high concentration will be hazardous to the inhabitants due to long time exposure through ingestion of food and water. According to Maloney, 1996 and Smedley and Kinniburgh, 2002, the overexposure to this element can cause various diseases such as cancer (skin, lung, bladder, and kidney), hair loss and nails deformity. This is in conformity with the present study in which some of the inhabitant's shows manifestation of some of these diseases which may be linked to arsenic toxicity.

4.1. Arsenic Concentrations in Waters and Effects on Health in Biu Volcanic Province North-Eastern Nigeria

The World Health Organization 2008, stated that safe limit for arsenic in drinking water is 0.01, it is clear that excessive arsenic is being consumed in drinking water at; Waka (0.224 and 0.389 mg/L), Hena (0.116, 0.123 and 0.229 mg/L), Yimrshika (0.136 and 0.477 mg/L), Wakama (0.315 mg/L), Biu (0.227 mg/L) and Kunar (0.424 mg/L). These areas are delineated as high risk zone to arsenic exposure.

For example the inhabitant of Yimirshika relies on their Spring Water which contains unsafe levels of dissolved arsenic for drinking, cooking and other domestic purposes. These findings indicate that they are over-exposed to this toxic metal through the ingestion of water and food.

Due to long time exposure, few of the inhabitants show manifestations of nail deformity (nail thickening and brittleness), and hyper-pigmentation of the skin and hand palms. Others present various forms of skin diseases (especially skin growth) which all could be attributed to exposure to arsenic toxicity. Plate 1-3 shows nails deformation and skin problem.

Plate 1 and 2. *Shows deformed nails due to arsenic toxicity (12°14□41.4′10°31□52.2′)*

Plate 3. *Growth on skin due to arsenic toxicity (12°14□41.4′10°31□52.2′)*

5. Summary and Conclusions

Areas identified with high arsenic in surface and groundwater of the province shows that the inhabitants of these areas have symptoms of arsenic exposure, such as diabetes, loss of hearing, hair loss, deformed nails and various skin problems like: rashes, abnormal growth, skin lesion and roughness.

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